Table 1. Laboratory results of physical, mechanical properties and ultrasonic pulse velocity (UPV) measurements of specimens.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Specimen  No | ()  (gr/cm³) | (n)  % | Sa  (%) | e | Schmidt Hammer  (RN) | UCS  (MPa) | Is(50)  (MPa) | (UPV)  (m/s) |
| 1 | 2.52 | 7.895 | 0.35 | 0.095 | 31 | 37.69 | 3.67 | 4409.0 |
| 2 | 2.54 | 6.136 | 0.34 | 0.092 | 42 | 41.98 | 3.66 | 4666.7 |
| 3 | 2.61 | 3.486 | 0.32 | 0.035 | 50 | 51.87 | 4.56 | 5454.5 |
| 4 | 2.62 | 5.128 | 0.33 | 0.058 | 49 | 49.26 | 4.38 | 5070.0 |
| 5 | 2.56 | 6.542 | 0.33 | 0.081 | 45 | 44.78 | 3.98 | 4876.0 |
| 6 | 2.56 | 5.997 | 0.33 | 0.080 | 48 | 43.98 | 4.21 | 4963.5 |
| 7 | 2.55 | 6.275 | 0.34 | 0.080 | 37 | 44.43 | 4.18 | 4745.6 |
| 8 | 2.55 | 7.345 | 0.35 | 0.087 | 33 | 40.89 | 3.90 | 4680.0 |
| 9 | 2.54 | 7.683 | 0.34 | 0.086 | 35 | 39.54 | 3.24 | 4575.6 |
| 10 | 2.58 | 6.875 | 0.34 | 0.048 | 47 | 48.78 | 4.37 | 4942.6 |
| 11 | 2.53 | 7.336 | 0.34 | 0.087 | 26 | 42.00 | 3.73 | 4595.3 |
| 12 | 2.55 | 7.983 | 0.34 | 0.088 | 28 | 38.53 | 3.55 | 4560.0 |
| 13 | 2.55 | 6.212 | 0.34 | 0.075 | 33 | 47.16 | 4.56 | 4825.7 |
| 14 | 2.57 | 6.874 | 0.33 | 0.076 | 36 | 45.11 | 4.30 | 4798.6 |
| 15 | 2.59 | 5.337 | 0.33 | 0.054 | 25 | 51.00 | 4.67 | 5160.0 |
| 16 | 2.61 | 4.799 | 0.34 | 0.052 | 22 | 46.87 | 4.12 | 5145.8 |

Table 2. Relationships developed among the physical, mechanical and ultrasonic pulse velocity (UPV) values.

|  |  |
| --- | --- |
| UCS =9.4678Is(50) + 6.1065 | R2 = 0.8088 |
| UCS= 0.0146(UPV)-26.227 | R2 = 0.8426 |
| n = -0.0042(UPV)+ 26.688 | R2 = 0.8643 |
| e = -6E-05(UPV)+ 0.3784 | R2 = 0.8585 |
|  = 1E-04(UPV)+ 2.0873 | R2 = 0.8074 |
| Sa=-3E-0.5(UPV)+0.4704 | R2 = 0.8088 |
| RN=0.0266(UPV)-88.903 | R2 = 0.7216 |

Table 3. Relations between UCS and Is(50) given by different authors and this study.

|  |  |
| --- | --- |
| Author | Model |
| D’andre et al., (1964) | UCS=15.3 Is(50)+16.3 |
| Broch & Franklin (1972) | UCS=24 Is(50) |
| Bieniawski (1975) | UCS=23 Is(50) |
| Hassani et. Al., (1980) | UCS=29 Is(50) |
| Read et al., (1980)  For sedimentary formation  For bazalt | UCS=16 Is(50)  UCS=20 Is(50) |
| Forster (1983) | UCS=14.5 Is(50) |
| Gunsallus and Kulhway (1984) | UCS=16.5 Is(50)+51 |
| ISRM (1981) | UCS=25 Is(50) |
| Cargill and Shakoor (1990) | UCS=23 Is(50)+13 |
| Grasso et al., (1992) | UCS=9.30 Is(50)+20.04 |
| Chau and Wong (1996) | UCS=12.5 Is(50) |
| Kahraman (1996)  For semi coal formation  For other formation | UCS=23.62 Is(50)-2.69  UCS=8.48 Is(50)+9.51 |
| Başarır and Kumral (2004) | UCS = 10.957 Is(50) |
| This study | UCS =9.4678Is(50) + 6.1065 |

Table 4. The relations between UCS and UPV given by different authors and this study.

|  |  |
| --- | --- |
| Author | Model |
| Inoue and Ohomi (1981) | UCS=kγVp2+A |
| Goktan (1988) | UCS=0.036Vp-31.18 |
| Kahraman (2001) | UCS=9.95Vp1.21 |
| Başarır and Kumral (2004) | UCS = 0.68 ρ Vp2.69 |
| This study (UPV=Vp) | UCS= 0.0146Vp-26.227 |